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ECE322L -Homework 3 (100 points)
Assigned on Thursday, 02/13/2020-11 am
Due on Thursday, 02/20/2020-11 am

The transistor parameters of the NMOS in the figure below are V_{TN} = 0.4 V, K_n = 100 μA/V², and l = 0.

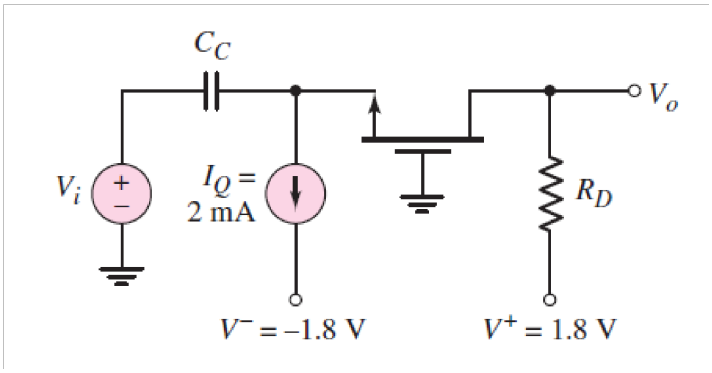
(a) Determine R_D such that $V_{DSQ} = V_{DS(sat)} + 0.25$ V.

(b) Determine the transistor W/L ratio such that the total small-signal voltage gain is $A_V = 6$.

(c) What is the value of V_{GSQ}?

(d) What are the input and the output resistance of the amplifier?

(e) Please, comment on the performance of the circuit below as a voltage amplifier.



(a) $V_{DSQ} = V_{out} + V_{GS} \quad \rightarrow \quad V_{out} = V_{DSQ} - V_{GS} \quad \rightarrow \quad V_{out} = \cancel{V_{GS}} - V_{TN} + 0.25 - \cancel{V_{GS}}$

$$V_{out} = -0.4V + 0.25V = -0.15V$$

$$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{1.8V - (-0.15V)}{2mA} = 975\Omega$$

(b) $A_V = g_m R_D = 6V \quad \rightarrow \quad g_m = \frac{6V}{975\Omega} = 6.1538\frac{mA}{V}$

$$g_m = 2\sqrt{K_n I_D} = 2\sqrt{\frac{k_n'}{2}\left(\frac{W}{L}\right) I_D} \quad \rightarrow \quad \left(\frac{W}{L}\right) = \frac{\left(\frac{g_m}{2}\right)^2}{\frac{k_n'}{2} I_D} = 94.6745$$

(c) $I_{DQ} = K_n \left(V_{GS} - V_{TN}\right)^2 \quad \rightarrow \quad V_{GS} = \sqrt{\frac{I_{DQ}}{K_n}} + V_{TN}$

$$= \sqrt{\frac{2mA}{\frac{100\frac{\mu A}{V^2}}{2} \times 94.6745}} + 0.4V = 1.05V$$

(d) $R_{in} = \frac{1}{g_m} = \frac{1}{6.1538\frac{mA}{V}} = 162.5\Omega$

$R_{out} = R_D = 975\Omega$

(e) As a voltage amplifier, this circuit would not be very practical. While the gain is positive and large (good qualities), the input resistance is very low which makes for a great current buffer, but is not ideal for a voltage amplifier.